CATECHISM OF THE ELECTRIC HEADLIGHT

Brotherhood of Locomotive
" Firemen and Enginemen,

CATECHISM

OF THE

ELECTRIC HEADLIGHT

PUBLISHED BY
BROTHERHOOD OF LOCOMOTIVE
FIREMEN'S MAGAZINE

INDIANAPOLIS
Wm. B. Burford, Printer and Binder
1906

PREFACE

In the early part of 1905 the Brotherhood of Locomotive Firemen's Magazine commenced the publication of a series of articles on the Pyle National Electric Headlight by Mr. J. Will Johnson, who, from his connection with the company and his experience with this particular headlight, was well adapted to do the work. These articles were followed up by Mr. Johnson in the Magazine with a very full and complete list of Questions and Answers on this subject, which have been so well and favorably received by the readers of our publication that the Editor and Manager thought best to publish same in book form. Arrangements were therefore made with Mr. Johnson to revise and rewrite these Questions and Answers and bring same fully up to date.

This work on the Pyle National Electric Headlight consists of 296 Questions and Answers on that all important subject to the locomotive enginemen of today.

In view of the high speed at which trains are operated today on the great railway systems of this country, it be-

comes essential to the safety of life and property to equip the locomotives with headlights of sufficient illuminating power that the enginemen may be enabled to observe an obstruction or defect in the track at a much greater distance than under moderate speed conditions, so as to avoid accident.

The electric headlight has been so perfected that, with the shaft of light which it throws far in advance of the onrushing train, the darkness of night is practically turned into daylight, and it is next to impossible for such a catastrophe to take place.

This little volume is well adapted for use in the examination of firemen for promotion, and will form a valuable text-book for the progressive student who has the desire to better his condition and broaden his knowledge of a subject with which it is essential for him to be familiar. It is with this object in view that this work is now offered to locomotive enginemen, and if it fulfills that mission the publisher will feel amply rewarded.

BROTHERHOOD OF
LOCOMOTIVE FIREMEN'S MAGAZINE.
Indianapolis, Ind.

Questions and Answers on the Pyle National Electric Headlight

BY J. WILL JOHNSON.

Question 1.—Give the definition of an electric headlight?

Answer.—An electric headlight is an electrical device applied to the front of a locomotive for the purpose of illuminating the track ahead.

Q. 2.—What are the principal parts comprising this headlight?

A.—They are three in number—the turbine engine, the dynamo and the arc lamp.

Q. 3.—What is the chief duty of the turbine engine?

A.—To furnish the mechanical power that operates the dynamo.

Q. 4.—What produces the light?

A.—The light is produced by the dynamo.

Q. 5.—Name the principal parts of the dynamo?

A.—The armature, with the commutator attached thereto, the two field magnets and the pole pieces.

Q. 6.—What are the functions of the armature?

A.—To induce an electro-motive force

in the wires wound upon its surface, and to concentrate and direct the flow of current.

Q. 7.—What is required of the commutator?

A.—To gather together the currents produced by the wires wound upon the armature, and to cause them all to concur to a desired result.

Q. 8.—At what point is the commutator attached to the armature?

A.—The commutator is attached to the end of the armature shaft in such a manner as to rotate with it.

Q. 9.—Give the formation of the commutator?

A.—The commutator is composed of copper bars, to which the armature wires are attached at one end. These copper bars are separated from each other by pieces of mica, which is a nonconducting material.

Q. 10.—What is the duty of the field coils or magnets?

A.—To produce a magnetic field, in which the armature revolves.

Q. 11.—Define the pole pieces and give their requirements?

A.—The end portion of the field magnet are called the pole pieces; they form the armature chamber in which the armature revolves.

Q. 12.—Give the first three measurements of electricity?

A.—The volt, the ampere and the ohm.

Q. 13.—Define the volt?

A.—The practical unit of measurement of *electrical pressure* is the volt.

Q. 14.—Define the ampere?

A.—The practical unit of measurement of the *rate of flow of current* is the ampere.

Q. 15.—Define the ohm?

A.—The practical unit of measurement of *electrical resistance* is the ohm; a resistance that would limit the flow of electricity under an electro-motive force of one volt to a current of one ampere.

Q. 16.—Where is electricity to be found?

A.—Electricity pervades all bodies—it is found everywhere.

Q. 17.—Does electricity have weight?

A.—No, electricity does not represent weight. Being intangible and having no substance it can not have weight or occupy space.

Q. 18.—Tell how electricity is conducted into our stores and dwellings, or from the dynamo to the lamps?

A.—Copper wires are used for the purpose of conducting electricity from the dynamo to the lamp.

Q. 19.—What means are employed to prevent the electricity from escaping?

A.—The copper wires are covered with various substances, such as rubber, asbestos, etc., to prevent the escape of the electricity.

Q. 20.—What is this covering on the wires called?

A.—It is called insulation.

Q. 21.—Why does water flow through the pipes into our stores or dwellings when we open the valves or faucets?

A.—Because of pounds pressure, or head.

Q. 22.—Should the pounds pressure in the pipes become too great, what would result?

A.—We would have bursted pipes and escaping water.

Q. 23.—What is it that causes the electricity to flow through the wires and lamps?

A.—The electro-motive force, or voltage, causes the electricity to flow through wires and lamps.

Q. 24.—In what manner is the electro-motive force, or voltage, produced?

A.—The armature revolving in its chamber at a very high rate of speed produces the electro-motive force, or voltage, in the armature wires.

Q. 25.—If the speed of the armature

is increased beyond the point desired, what results?

A.—The electrical pressure, or voltage, becomes too high.

Q. 26.—Does the speed at which the armature revolves determine the amount of voltage produced?

A.—Yes. The amount of voltage produced is governed by the speed of the armature.

Q. 27.—What will result if the electrical pressure becomes too great?

A.—In case the electrical pressure, or voltage, becomes too high, the wires which conduct the current will become so hot that the insulation which is wound upon them will become charred, and it may even take fire and burn up.

Q. 28.—If the insulation on the wires becomes charred, does it lose its usefulness?

A.—Yes. Should the material covering the wires become charred it is no longer a perfect insulator, and the current, leaking through from layer to layer of the coils, will escape.

Q. 29.—When the insulation is burned or charred, what term is applied to it?

A.—It is called a burned-out coil.

Q. 30.—Is any amount of electricity represented by the volt?

A.—No, the volt does not represent an

amount of electricity, but only the *pressure* which acts upon the electricity.

Q. 31.—In what manner does the volt affect a current of electricity?

A.—The volt forces a certain quantity of current to flow through the wires at a given rate per second.

Q. 32.—In what way is this rate of flow of current measured?

A.—It is measured in amperes.

Q. 33.—What means do we employ to cause a current of electricity to perform some work for us?

A.—We accomplish this result by placing opposition in the path of an electric current.

Q. 34.—Is any resistance offered to the flow of current by the wires through which it passes?

A.—Yes. The passage of electrical current through copper wire is much like the passage of water through a pipe, except that the wire is solid and the pipe hollow, and the wire offers resistance to the flow of current just as the water pipe does to the water, and, as in the case of the water, the resistance to the passage of electricity is greater if a large quantity is passed through than a small one.

Q. 35.—Should you find it necessary to conduct a quantity of electricity a cer-

tain distance, and for that purpose should use two or more small wires of the same size or one large wire, would the resistance be less than if one small wire was used?

A.—The resistance would be very much reduced; which would cause the current to flow more easily.

Q. 36.—Will electricity take any path that may be offered?

A.—Yes, electricity will take any or all paths that may be offered, but will always take the easiest or the one offering the least resistance to its flow.

Q. 37.—Tell what is meant by the term, "short circuit"?

A.—By a "short circuit" we mean that some passage is opened whereby a quantity of electrical current may flow with less resistance than is offered by its passage to points of usefulness, such as lamps, etc.

Q. 38.—What causes the majority of short circuits in the Pyle National Electric Headlight?

A.—Distorted insulation of wires, which is caused by chafing.

Q. 39.—Can this chafing of the insulation from the wires be avoided?

A.—If the wires are carefully and properly protected when an equipment is applied these difficulties will not occur.

Q. 40.—Describe the manner in which the wires should be run from the dynamo to the lamp, when the dynamo is applied near the cab of the locomotive?

A.—The wires to the arc lamp should be run through a separate pipe, and *inside of a molding*, when the dynamo is applied near the cab of the locomotive.

Q. 41.—Tell why it is impracticable to place these wires inside of the hand-railing?

A.—There are several reasons why the wires from the dynamo to the arc lamp should not be placed within the hand-railing. First, frequently the hand-railing must be removed when staybolt work is done and the boilermakers might be careless in removing same and cause damage to the insulation on the wires, and this might not be noted until a failure had resulted. Second, because of the abrupt angle at which the wires are bent, there is much danger of the insulation being chafed off or the wires broken where they enter or leave the hand-railing. Third, should water get inside of the hand-railing and not drain out, in time it would moisten and rot the insulation until the water could soak through, and when the insulation has become moist it has lost its virtue.

Q. 42.—Describe the manner in which

the wires should be run from the dynamo to the arc lamp when the dynamo is applied at the front, or on the arch of the locomotive?

A.—The wires should pass through a piece of "circular loom" or a piece of rubber hose, and this conduit should be passed through to the inside of the reflector case when the dynamo is applied at the front or on the arch of the locomotive.

Q. 43.—What is the best method of wiring the cab of a locomotive to avoid future trouble?

A.—When wiring for the cab lamps, run the wires from the dynamo into the cab through an iron pipe or a piece of circular loom conduit and under a molding in the top of the cab. Should the iron pipe be used, the wires must be carefully wrapped with insulation tape where they enter and leave the pipe.

Q. 44.—The engine that furnishes the mechanical power that operates the dynamo is known by what name?

A.—It is called the Pyle compound steam turbine.

Q. 45.—Describe the construction of the Pyle compound steam turbine and the passage of steam through same.

A.—This turbine engine consists of a main casting having three rows of ex-

haust or receiving buckets; the turbine wheel which revolves in this casting has three rows of bottomless buckets or blades that are solid cast in the wheel, and that fit into a recess in the main casting in such a manner that the steam may pass from the blades of the wheel to the exhaust buckets of the casting and back into the next row of bottomless buckets in the wheel, and so on until it passes into the central exhaust chamber, thence to the atmosphere.

Q. 46.—Is any internal lubrication required for this turbine engine?

A.—It requires no internal lubrication, for the reason that it has no reciprocating parts.

Q. 47.—The speed of this device is controlled by some mechanical means. What is it?

A.—A governor, which is applied within the casing of the engine, controls the speed of this device.

Q. 48.—What is the style of governor used?

A.—This governor is of the centrifugal form.

Q. 49.—Do we find any other appliance within this turbine engine to prevent the speed from attaining a velocity beyond the point desired?

A.—Yes, we will find, in all of the

machines that have been applied in the last four years, that the turbine wheel is supplied with a centrifugal brake, and this is set to act at about 150 revolutions higher speed than the point at which the governor is set to act.

Q. 50.—Why is it necessary to set this centrifugal brake to act at a higher rate of speed than that of the governor?

A.—The centrifugal brake is set to act at a higher rate of speed than the governor for two reasons. First, from the fact that the brake will not act as quickly as the governor weights, it will be seen that were the brake set to act in conjunction with the weights it would seriously interfere with the speed at the critical time. Second, the centrifugal brake was designed and applied to prevent any possibility of the turbine wheel running away and being thrown to pieces by centrifugal force at times when the governor valves have been neglected, etc.

Q. 51.—How many governor weights are found in this device?

A.—There are four governor weights in this device.

Q. 52.—Mention how many sets of governor springs are used in this device, and their duty?

A.—We will find that there are four sets of governor springs used in this de-

vice, and the duty of these springs is to offer the proper amount of resistance to the movement of the governor weights and also to cause them to act quickly.

Q. 53.—How many governor valves are there in this device, and where are they located?

A.—Two governor valves are used for admitting the steam to the turbine wheel, and they are placed within the governor stands.

Q. 54.—At what point are the governor stands located?

A.—The governor stands are suspended to the main casting and at diametrically opposite points.

Q. 55.—What is the effect upon the governor weights when the steam is turned on and motion given to the turbine wheel?

A.—When the turbine wheel is started in motion the governor weights tend to fly farther apart, from the fact that they are attached to the turbine wheel and revolve about the vertical axis of the shaft.

Q. 56.—What does this action of the governor weights cause?

A.—This action of the governor weights forces the cross arm out, and it in turn moves the two governor valves in toward their seats and thus diminishes the vol-

ume of steam that is flowing to the turbine wheel.

Q. 57.—Would the governor be able to control the speed if the governor weights were allowed to travel out farther than at right angle position to the face of the turbine wheel before the governor valves are seated?

A.—It would not.

Q. 58.—Will it be found necessary at any time to change the governor if it is set so that the valves are seated when the governor weights are drawn at right angle position to the face of the turbine wheel, and why?

A.—The action and position of the governor valves are determined by the position of the governor weights, the position of the latter being controlled by the speed at which the turbine wheel revolves. Should the valves be set in such a manner that they are carried to the seat of the steam supply, when the weights are thrown to the point of least resistance, it will be found when the governor valves have become worn and must be faced off that they will not seat when the governor weights are drawn to the above stated position, and it will now be necessary to bend the ends of the cross-arm until the valves will seat.

Q. 59.—Should it be found that the

governor weights will over-travel, that is, should they be drawn beyond a position at right angles to the face of the turbine wheel before the governor valves may be seated, in which direction must the ends of the cross-arm be bent to cause the governor valves to seat firmly when the governor weights are drawn to critical service position?

A.—When the weights are drawn to critical service position, which is at right angle to the point of suspension or the face of the turbine wheel, the ends of the cross-arm must be sprung out—away from the wheel—until the valves will seat firmly.

Q. 60.—Describe how this work should be done in order that both governor valves may have the same travel?

A.—When it is found that the governor valves will not seat firmly when the governor weights are drawn to right angle position to the face of the turbine wheel, the ends of the cross-arm *36* must be bent back—out—away from the face of the turbine wheel until the governor valves will seat when the governor weights are drawn to a position straight out from the wheel.

Q. 61.—How often do we find it necessary to examine the governor valves to insure ideal service?

A.—A competent inspector should make a thorough examination of the governor valves once each month, and he should be provided with a book in which to keep a record of all such inspections.

Q. 62.—When the governor has been properly set, for what length of time will this device run before the governor valves may need to be faced off?

A.—For at least six months.

Q. 63.—Why then should we find it necessary to remove the engine cap and make an examination of these governor valves once in every month?

A.—This governor is of the centrifugal form and is set to act at the maximum speed which this engine should attain, which is at the point of the maximum output desired that the dynamo shall deliver. In bad water districts the locomotive boiler may foam, or the engineer get too much water in the boiler, and some of this water is sure to pass through the turbine engine, which would be certain to cause the governor valves to stick. If they should stick open, a very high electro-motive force would be built up and the copper electrode and holder might be destroyed, hence the necessity of the regular monthly inspection.

Q. 64.—Is it absolutely necessary to remove the engine cap in order to as

certain whether or not the governor valves are stuck?

A.—No, it is not always necessary to remove the engine cap to find if the governor valves are stuck, as it can be determined by taking the speed with the load on, then with the turbine running without a load.

Q. 65.—How does the speed recorder determine when one of the governor valves is stuck "shut"?

A.—When the governor has been handling the load, that is, when the governor has been set on a wide open throttle, should one of the valves stick shut the speed will be low with the light burning, but when the load is taken off the speed will at once attain the maximum.

Q. 66.—How shall we determine if one of the valves is stuck "open"?

A.—The copper electrode will be fused almost instantly if the governor valve is stuck open, and when the load is taken off the speed of the turbine will become excessive. A constant and heavy flow of steam from the exhaust pipe can also be noted with little variation.

Q. 67.—By what means is the centerpiece and the face of the cross-arm, *36*, lubricated?

A.—By what is known as the "graphite ring."

Q. 68.—Give description of this graphite ring and its location?

A.—The graphite ring is a flat bronze ring drilled full of holes, and these holes are filled with graphite. The ring is placed in a small recess in the centerpiece and is held in position by the cross-arm.

Q. 69.—How often does it become necessary to renew this graphite ring?

A.—The graphite ring will wear indefinitely—no actual time limit can be given to its life and wear.

Q. 70.—When the governor valves have correct travel and all parts are in good condition, in what way can the speed of the turbine engine and dynamo be increased?

A.—To increase the speed of the turbine and dynamo, move *all* of the adjusting screws, *117*, of the governor springs to the *right*.

Q. 71.—In what manner may the speed of the turbine and dynamo be decreased?

A.—To decrease the speed of the turbine and dynamo, move *all* of the adjusting screws, *117*, of the governor springs to the *left*.

Q. 72.—How far should the adjusting screws be turned to increase the speed of the dynamo 100 revolutions per minute?

A.—All of the adjusting screws, *117*, must be moved one-half turn to the *right* in order to increase the speed of the dynamo 100 revolutions per minute.

Q. 73.—And to decrease the speed of the dynamo in the same proportion, how shall we proceed?

A.—To decrease the speed of the dynamo 100 revolutions per minute, move all adjusting screws, *117*, one-half turn to the *left*.

Q. 74.—Is there a possibility that the adjustment of the governor-spring screws will not cause the engine to respond to the desired speed at all times?

A.—Yes, there are various things that will, at certain times, prevent the regulation of the speed of the dynamo by changing the adjustment of the governor-spring screws.

Q. 75.—Mention one cause that will interfere with the regulation of speed by means of the adjusting screws?

A.—When the bearing in the engine cap has not been properly lubricated and has become worn from lack of lubrication the turbine wheel will have been lowered in the casing and it will then be found that the edge of the bottom governor stand has been worn off by the turbine wheel, which has slowly dropped down by this bushing wear until it has come

in contact with the governor stand; and in a short time the space between the governor stands and turbine wheel will be increased until it will not be necessary for the steam to pass through the turbine wheel to gain the atmosphere, but can pass around on either side of the wheel to the exhaust. In such a case, adjustment of the regulating screws could not be effective.

Q. 76.—Give a second reason why adjustment of the governor-spring screws, *117*, will fail to regulate the speed of the turbine engine?

A.—The adjustment of the governor-spring screws will fail to regulate the speed of the engine if the bearings are not properly lubricated and the end thrust is maintained too close. Since the steam is directed against the buckets of the wheel by the governor stands, the latter being suspended to the main casting, in a short time the flange of the bushings and the cast-iron washer in the engine cap will be worn so badly that the turbine wheel will be carried out and away from the main casting and governor stand by this end thrust adjustment. The steam not now being directed against the center of the buckets in the wheel, but against the side of the wheel, will be allowed to pass around to the back side of

the turbine wheel to the exhaust, instead of passing through the wheel.

Q. 77.—Give a third reason why the adjustment of the governor-spring screws will be ineffectual in controlling the speed of the turbine engine?

A.—Should one of the governor valves stick either open or closed, it would be found impossible to regulate the speed of the engine as desired by movement of the adjusting screws while the valve remained in such condition.

Q. 78.—Should the end thrust always be adjusted before the engine cap is removed?

A.—Yes. Always see that the end thrust is adjusted to 1-32 of an inch before the engine cap is removed.

Q. 79.—Why is this adjustment necessary?

A.—Should it be found necessary to make some changes in the governor, such for instance as changing the cross-arm, etc., unless the end thrust has been adjusted *before* such changes are made, there is great danger that the travel of the governor valves might be reduced, and perhaps closed entirely.

Q. 80.—Tell the manner in which the adjustment of the end thrust is made?

A.—The adjustment of the end thrust movement is made in this way: when facing the dynamo, first loosen both the

screws in the end thrust casting, then tap the casting on the left side and this will take up or shorten the end movement. Tap the end thrust casting on the right side to loosen or increase the end movement.

Q. 81.—What is the remedy when it is found that, due to the end thrust casting being worn by too close adjustment, the turbine wheel has been carried away from the governor stands until the steam can not be directed against the center of the buckets in the wheel?

A.—A new cast-iron washer, *33*, and a new bushing, *17*, in the engine cap will be required.

Q. 82.—What substitute may be used if there are no new parts at hand to make repairs?

A.—Should we have no new parts convenient, temporary repairs may be made in the following way: First, loosen the screws in the end thrust casting and move this casting to the right, then move the wheel in toward the main casting as far as it will go and place a metallic washer between the flange of bushing in the engine cap and the cast-iron washer, and be careful that this washer is only of sufficient thickness to take up the lost motion between the flange of bushing and the cast-iron washer.

Q. 83.—Should you get this metallic

washer too thick in making your temporary repairs, what would result?

A.—It would be impossible to return the engine cap to place.

Q. 84.—Can you now say that the speed of the turbine engine and dynamo is always influenced to a marked degree by changing the tension of the regulating springs?

A.—It is now quite clear that the speed of the turbine engine and dynamo is not always influenced by changing the tension of the regulating springs. Other conditions must first be looked into and reckoned with.

Q. 85.—At what point of the wheel is the centrifugal brake applied?

A.—We will find that the centrifugal brake is placed on the back side of the turbine wheel, being fastened to the wheel by screws and then riveted.

Q. 86.—Tell the manner in which this brake is adjusted?

A.—For the purpose of adjusting the centrifugal brake, remove the armature, engine cap and governor, pull out the wheel and shaft and you will have free access to the brake.

Q. 87.—How can the centrifugal brake be adjusted to act at a lower speed than that at which you may find it set to act, if you should wish to have the brake act at a lower speed?

A.—By turning all of the adjusting nuts, *136*, to the *left*.

Q. 88.—How can the centrifugal brake be adjusted to act at a higher speed?

A.—By turning all of the adjusting nuts, *136*, to the *right*.

Q. 89.—One half turn of the adjusting nuts, *136*, either to the right or left, changes the point of speed at which the brake acts how much?

A.—By moving all of the adjusting nuts, *136*, one-half turn you change the point of speed at which the brake will act 150 revolutions.

Q. 90.—Will it be found necessary to readjust the centrifugal brake if the correct travel of the governor valves is maintained?

A.—It will seldom, if ever, be found necessary to readjust this brake if the correct travel of the governor valves is maintained.

Q. 91.—Describe the manner in which the cast-iron washer is secured that it may revolve with the turbine wheel shaft.

A.—A small dowel pin, which is made to enter the hub of the turbine wheel, sustains the cast-iron washer and causes it to revolve with the turbine wheel shaft.

Q. 92.—Do these dowel pins sometimes break off?

A.—It is not an unusual occurrence for these dowel pins to break.

Q. 93.—Mention some reason for these dowel pins breaking?

A.—The dowel pin is liable to break if the equipment is run with too much end thrust, thus allowing the washer to move the dowel pin out of the recess.

Q. 94.—Give another reason for the breaking of the dowel pins.

A.—Maintaining the end thrust too close with insufficient lubricant will cause the dowel pins to break.

Q. 95.—What would be the result if this dowel pin should break?

A.—The washer could not revolve with the wheel but would be loose on the shaft, thus causing the hub of the turbine wheel to chafe and wear the thin back surface of the washer, which action will soon increase the end thrust beyond the point desired.

Q. 96.—Is it necessary to note the condition of this cast-iron washer and dowel pin when the engine cap is removed for inspection or other work?

A.—Yes, it is quite essential to know that the cast-iron washer and dowel pin are in proper condition, and under no circumstances allow the cast-iron washer. *33*, to run without the dowel pin.

Q. 97.—Should the end thrust be taken up when the equipment is cold?

A.—It should always be taken up when the equipment is cold.

Q. 98.—Give the reason?

A.—If the adjustment of the end thrust is made when the equipment is cold, when it is heated up and expansion takes place it will not be too tight if adjusted to 1-32 of an inch.

Q. 99.—Tell why the end thrust should not be taken up closer than 1-32 of an inch.

A.—Should we adjust the end thrust to a movement less than 1-32 of an inch there would be great danger of the engine "binding" between the cast-iron washer and the flange of bushing when the steam was turned on and the engine and casing heated up, and the engine might be completely stalled, or if not it would be slowed down to a point at which it could not satisfactorily accomplish its work.

Q. 100.—What would result if the end thrust casting, with which we adjust this movement, should become loosened on the shaft?

A.—When we face the dynamo we find that the armature and shaft turn to the right. In order to take up or decrease the end movement this end thrust casting should be moved in the opposite direction from that in which the shaft rotates. If the screws which secure this casting to the shaft should become loosened, the shaft which is revolving at a

very high rate of speed would tend to run away from the adjustment casting. This casting is a worm screw device, and would move up on the shaft until its own flange and the cast-iron washer in the engine cap would be carried against the flange of bushings and the engine would stall.

Q. 101.—How can the engineer instantly locate such trouble?

A.—The engineer can easily locate such trouble from the fact that when the turbine engine is stalled by this casting becoming tightened on the shaft the steam will blow very hard at the exhaust, and it will be impossible to move the armature or shaft by hand as can be done very easily at all other times.

Q. 102.—When this trouble occurs what should be done to remedy it?

A.—To remedy this trouble, when facing the dynamo move the end thrust casting to the right until the engine is free, then adjust the end thrust movement to 1-32 of an inch, being careful to tighten the two screws securely.

Q. 103.—What precaution should be taken to prevent the governor valves from sticking?

A.—The sticking of the governor valves may be prevented in the following manner: Remove the ¾-inch plug

at the top of the engine casting each trip before starting the equipment, and introduce a small amount of coal oil or black oil at this point. Then when the steam is turned on to the turbine engine this oil will be blown through the governor stands and around the governor valves, and will cut away any scale that may have started to form.

Q. 104.—Should oil be introduced at this point to lubricate the turbine engine or the governor valves?

A.—No. This engine requires no internal lubrication for the reason that it has no reciprocating parts.

Q. 105.—Give the number of bearings within this device.

A.—This device has two bearings.

Q. 106.—Give the location of these two bearings.

A.—The shorter bearing is placed in the engine cap casting and supports the weight of the turbine wheel. The longer or main bearing is found in the box yoke and carries the weight of the armature.

Q. 107.—In what manner are these bearings lubricated?

A.—These bearings are each provided with an oil cellar into which a small loose ring is suspended around the shaft and a part of the top of each bushing

is cut away, thus allowing the oil ring to turn with the shaft. This oil ring is carried around with the shaft as it revolves, and passing through the oil in the oil cellar carries a part of the oil up to the top of the shaft, where it passes through the grooves in the bushings to the bearing proper.

Q. 108.—Should the same grade of oil be used for both of these bearings?

A.—The same grade of oil should not be used for both bearings in all cases; particularly is this a fact in the winter.

Q. 109.—What kind of oil is best for use in the small bearing in the engine cap?

A.—It is always advisable to use valve or cylinder oil for the bearing in the engine cap.

Q. 110.—For what reason is it necessary to use an oil with as heavy body as valve or cylinder oil in this bearing?

A.—It would not be practicable to use an oil of a lower flashing point than cylinder oil for this bearing, on account of the heat in the engine cap and the presence of steam.

Q. 111.—How often should we oil this small bearing in the engine cap?

A.—Always just before starting the equipment or at the beginning of each trip.

Q. 112.—What quantity of oil is required to satisfactorily lubricate this bearing?

A.—Have only enough oil in the oil cellar that the loose ring may touch—this should not require more than two tablespoonfuls of oil.

Q. 113.—What should be attended to before oil is introduced into this oil cellar?

A.—Open the drain cock and allow the water of condensation always to be found in this oil cellar to drain off; then you must be sure that the drain plug is tightly closed before the oil is introduced into the oil cellar.

Q. 114.—If this drain cock is left open, what would result?

A.—The oil, of course, would pass out at once leaving the bearing dry, with the result that the shaft and bushing would be quickly destroyed.

Q. 115.—What kind or grade of oil should we use in the main bearing in the box yoke?

A.—We will find that the best results are usually obtained by the use of black or engine oil in the main bearing.

Q. 116.—Why can best results be obtained from the use of common engine oil in this bearing?

A.—For the reason that this bearing

is always practically cold, an oil with a heavy body would be unable to pass through the long grooves in the bushing, but would drop back into the oil cellar. This is especially true during the cold weather.

Q. 117.—Is it unsafe to use cylinder oil for this bearing?

A.—It is not safe to use cylinder oil for this main bearing except in the summer time or in the extreme South.

Q. 118.—What trouble will be met with by the persistent use of cylinder oil for the main bearing?

A.—It will necessitate the frequent renewal of the bushing.

Q. 119.—If this main bushing is properly lubricated, for what length of time should it run without renewal?

A.—If the proper lubricant is used, and used regularly, this bushing will run at least two years.

Q. 120.—Why is so small a quantity of oil required in the bearings of this device to insure successful operation?

A.—Very little oil is required in the bearings, for the reason that both the engine and the dynamo are perfectly balanced.

Q. 121.—Will the life and usefulness of this bushing be influenced to any great extent if the steam blows at the stuffing-box gland nut *21?*

A.—Yes, the bushing and shaft would be destroyed very quickly if the steam was allowed to blow at the stuffing-box gland nut, for the steam will follow along the shaft and blow off the oil which has been carried up by the loose ring and deposited on the bearing, leaving the bearing dry.

Q. 122.—Mention some other great damage which might result from the steam blowing at this point.

A.—Steam blowing at this point would soon destroy the insulation on the armature coils, for the reason that a portion of the oil, carried to the top of the shaft by the oil ring, would be blown against the armature coils.

Q. 123.—What is the best packing for use in the stuffing-box?

A.—You may make use of any soft packing, such as lamp wicking, etc., but never use asbestos.

Q. 124.—What quantity of oil should be introduced in the main bearing?

A.—Use only a sufficient amount of oil in the main bearing for the loose oil ring to trail in.

Q. 125.—Should the overflow holes in the oil cellar be regarded as a gauge for filling?

A.—If this cellar was completely filled with oil it would be thrown out by the oil ring from the opening in the top of

the casting. The overflow holes were placed in the casting to prevent such an occurrence, and the oil cellar should not be filled so full that the oil would run out through the overflow holes.

Q. 126.—Is there another reason why the oil cellar should not be filled so full of oil that it can be thrown out or will run out of the overflow holes?

A.—Aside from the fact that it would be a sheer waste of oil this lubricant thrown out would attract dirt around the dynamo, and this must be avoided as far as possible.

Q. 127.—How often should we oil this main bearing?

A.—It is seldom found necessary to oil the main bearing oftener than two or three times each week, though it should be examined before starting the equipment for each trip, to insure safety.

Q. 128.—What is likely to occur when the main bushing becomes badly worn?

A.—It must be replaced for this reason: The weight of the armature is supported by the main bearing, and, as the armature's clearance in the armature chamber is just sufficient to allow for its rotation and a reasonable wear to the bushing, were this bushing not renewed when it is founu to be worn, the armature would, in time, strike the pole pieces,

thus causing a short circuit in the dynamo.

Q. 129.—Give the maximum speed at which this turbine engine is intended to run.

A.—Eighteen hundred revolutions per minute.

Q. 130.—Give the minimum speed at which this turbine engine is intended to run.

A.—It should not be lower than sixteen hundred revolutions per minute in order to insure a good light at all times.

Q. 131.—What precaution should be observed in starting this equipment in operation?

A.—When starting the electric headlight, open the throttle to the steam turbine very slowly so that the water of condensation may pass out of the pipes and casting. This will also allow the steam to gradually heat the pipes and engine.

Q. 132.—Is there any other reason why this device should be started slowly?

A.—By starting the equipment in this manner you not only heat up the pipes and engine, but your throttle opening will not be too large for the speed at which you may desire to run your dynamo when the water of condensation is carried off. Hence, if the governor

valves were in need of attention and the steam was turned on rapidly with the throttle opened up wide, as soon as the water had passed out of the pipes and turbine engine the speed of the dynamo would become so great, and the electromotive force would be built up so high, that the copper electrode would be damaged.

Q. 133.—In what manner is the armature of this device made to revolve?

A.—The armature is attached to the engine shaft and is thus made to revolve with the turbine.

Q. 134.—How is the armature connected to the engine shaft—directly or by means of a coupling device?

A.—The armature is connected directly to the engine shaft and no coupling device is employed.

Q. 135.—Is it any great advantage to have the armature connected directly to the engine shaft?

A.—Yes, we gain this advantage: When the engine and armature are connected to the same shaft we avoid the difficulty of setting them in line with each other, as would be necessary if a special coupling device was used.

Q. 136.—In what manner is the armature held in place on the engine shaft?

A.—One screw holds the armature in

place on the engine shaft, and this can be easily removed if occasion demands.

Q. 137.—What is the number of brushes used with this dynamo?

A.—There are two brushes used with this dynamo.

Q. 138.—Is it possible to shift the position of these brushes on the commutator?

A.—The brush holders are rigid, hence it is impossible to shift the position of the brushes.

Q. 139.—Then it will be found impossible for the brushes to lose their polarity?

A.—It will not be possible for the brushes to lose their polarity.

Q. 140.—Is it possible for the brushes to be taken out and replaced or trimmed without changing the tension of the springs?

A.—It is not necessary to change the tension of the springs in order to remove, replace or trim the brushes.

Q. 141.—How many styles of brush holders are found in use on this dynamo?

A.—We will find two styles of brush holders in use on the Pyle National dynamos at the present time. One, the old style, has the flat straight bar spring, while the other, or later one, has a coil spring.

Q. 142.—In what manner is brush adjustment made with the old style brush holder?

A.—Adjustment of brushes is made by means of the adjusting screw when the old style brush holder is used.

Q. 143.—Is it possible for the engineer to change this tension at will?

A.—The engineer can regulate the tension of the old style brush holders only.

Q. 144.—Explain why the tension on the brush having the new style brush holder can not be changed as easily or as readily as the tension on the brush having the old style holder.

A.—It is more difficult to change the tension on the new style brush holder for the reason that it is supplied with a coil spring, and this spring is set or fixed with a predetermined pressure upon the brushes which will maintain a sufficient pressure upon them to prevent sparking until the brush is worn out. The tension of these springs can not be altered without removing the adjuster screw and spring adjuster, and for this purpose a heavy screw driver will be required.

Q. 145.—What was the chief difficulty with the old style brush holder, and why was it found necessary to adopt the new?

A.—With the old style brush holder the chief trouble was sparking at the

brushes, while with the new this trouble has been reduced to a minimum because of the predetermined pressure of the brush upon the commutator at all times, which could not be attained by the use of the old style holder.

Q. 146.—What usually causes sparking at the brushes?

A.—Sparking at the brushes is almost invariably caused by an imperfect contact between the commutator and the brushes.

Q. 147.—Why will an imperfect contact between the commutator and the brushes cause sparks between these points?

A.—The electric spark, or arc, is only seen or produced when an improper contact is made between two points, from one to the other of which an electric current is flowing; hence, when the brush does not touch the commutator freely and an improper contact is made sparking will be seen.

Q. 148.—How much greater resistance is offered to the passage of an electric current through an air space than is offered by its passage through a copper conductor?

A.—More than a million times greater resistance is offered to the passage of an electric current through an air space

than will be offered to its passage through a copper conductor.

Q. 149.—At about what rate of speed has it been determined by electrical engineers that an electric current will flow?

A.—It has been decided that an electric current travels at the unthinkable speed of 186,000 miles per second.

Q. 150.—If sparks are seen at the brushes when the old style brush holder is used, what course should be adopted to remedy the trouble?

A.—We should first see if the commutator is clean and free from dirt. If it is clean, and sparks are still seen, we must tighten the brush that is sparking until sparks are no longer seen. In order to tighten this brush, turn the adjusting screw, *110*, to the right.

Q. 151.—If sparks are seen when the new style brush holder is in use, what should be done?

A.—Sparking at the brushes when the new style brush holder is in use is almost invariably caused by a dirty commutator or brush, and the only remedy for that trouble is to stop the dynamo and clean the commutator and brushes.

Q. 152.—What will best serve the purpose for cleaning the commutator?

A.—A damp cloth or piece of waste is best for cleaning the commutator.

Q. 153.—How should the commutator be cleaned?

A.—To clean the commutator rub *lengthwise* of the bars with a clean, damp cloth, and after cleansing thoroughly wipe dry with a clean cloth or piece of waste.

Q. 154.—If the commutator continues to spark after being rubbed with a damp cloth and wiped perfectly clean and dry, what must be done?

A.—If the commutator is clean and sparking continues it is caused by an imperfect contact between the commutator and the brushes, and they must be cleaned with a piece of number "O" sandpaper.

Q. 155.—What is the method of cleaning the commutator with sandpaper?

A.—Both brushes must be removed when it is found necessary to clean the commutator with sandpaper, and then proceed in the following manner; Take a strip of number "O" sandpaper about the width of the brushes, and while the commutator is running work the sandpaper back and forth lengthwise of the commutator so as to cover the entire surface, and continue until the commutator is perfectly smooth.

Q. 156.—After thoroughly cleaning the commutator with sandpaper, what else

should be done before starting the dynamo in operation?

A.—After using the sandpaper on the commutator the brushes should be cleaned and fitted to the same contour as the commutator, and the commutator should be wiped perfectly clean and free from grit.

Q. 157.—How are these brushes fitted to the same contour as the commutator?

A.—When we have a new set of brushes to apply, or an old set to true up, we use a strip of number "O" sandpaper in the same manner as when cleaning the commutator, with the exception that the dynamo is not running when we are fitting or truing up the brushes. Place the sandpaper on the commutator with the rough side up or against the brush, and pull the sandpaper through and under the brush in the direction of the rotation of the armature and continue this until the brush is fitted to and has the same contour as the commutator.

Q. 158.—In fitting the brushes why do we pull the sandpaper through, under the brush in the direction of the rotation of the armature?

A.—By pulling the sandpaper under the brush in the direction of the rotation of the armature, the brush is drawn against the side of the brush holder,

where it is carried when in use by the rotation of the armature, and thus a perfect bearing is insured when the dynamo is in operation.

Q. 159.—What will result if the pressure of the brush against the commutator is too heavy?

A.—When the brush bears with too much pressure against the commutator it creates a great deal of frictional heat and causes unnecessary wear to both the commutator and brushes.

Q. 160.—With what pressure should the brush bear upon the commutator to secure the best results?

A.—The pressure of the brush upon the commutator bars should only be sufficiently heavy to collect the full strength of the current without allowing sparks to be seen. Pressure should also be heavy enough to overcome all vibration due to the rotation of the armature or the jar of the locomotive.

Q. 161.—Why is the shaft of this device given end thrust, or end movement?

A.—To prevent the scratching or grooving of the commutator.

Q. 162.—Why does end movement prevent the scratching of the commutator?

A.—The hard spots always found in the carbon brushes would cut and scratch the commutator until it would become

useless and the dynamo would refuse to build up, were it not for the end movement which allows the shifting of the commutator and brushes.

Q. 163.—If the brushes are allowed to spark for any length of time, what will result?

A.—*Flat spots* will be produced on the surface of the commutator.

Q. 164.—When flat spots are found on the surface of the commutator, what must be done?

A.—The armature must be taken out without delay and the commutator trued up in a lathe.

Q. 165.—Mention another cause that will prevent the brushes from touching the bars of the commutator.

A.—The commutator bars are separated from each other by pieces of mica used for the purpose of insulation. This mica is much harder than either the brush or the copper bars, and after the machine has been in service for some time the insulations will project above the surface of the copper bars and will prevent the brushes from touching the commutator at all times and will produce sparking.

Q. 166.—How do we prevent the mica insulations from interfering with the contact between the commutator bars and the brushes?

A.—To prevent the mica insulations from interfering with a perfect contact between the commutator bars and the brushes, cut or file out the mica until it is about 1-64th of an inch below the surface of the commutator bars.

Q. 167.—When cutting or filing down the mica, should we exercise great care to avoid increasing the width of the grooves between the copper bars of the commutator, and why?

A.—The grooves between the commutator bars fill up very quickly with dirt and carbon dust, and the deeper or wider the groove the greater the amount of dirt collected, and this would allow the current or a part of it to flow across the commutator bars, creating a short circuit; hence, we must use care and not increase the width or depth of these grooves when filing down the mica insulations.

Q. 168.—If the grooves fill up with dirt and are allowed to remain so, what will result?

A.—Not only would a short circuit be created in the commutator by dirt collecting in the grooves between the copper bars, but the commutator would spark badly.

Q. 169.—After filin~ or cutting down the mica, what should be attended to before the dynamo is started in operation?

A.—A slight burr will be raised on the edge of the copper bar when the mica is filed down, and this must be removed before the dynamo is placed in operation.

Q. 170.—Explain why it is necessary that this slight burr must be removed before the dynamo is started.

A.—This slight burr on the edges of the copper bars would tend to lift the brush from the bars and produce sparks, and would scratch and destroy the bearing surface of the brushes.

Q. 171.—In what manner is this burr removed?

A.—The burr is removed from the edges of the copper bars by using a piece of sandpaper in the same manner as when truing up the brushes.

Q. 172.—Why must the grooves between the commutator bars be carefully cleaned out after sandpaper has been used upon the commutator or brushes?

A.—For the reason that the small particles of sand that may have been deposited in the grooves will get between the brush and the commutator when the dynamo is started and will cause sparking, and will also cut and scratch both the commutator and the brushes.

Q. 173.—When the old style brush holder is used and sparks are seen at the brush points, what are the two most common causes for this?

A.—It will almost invariably be found that the sparks are produced by an insufficient pressure of the brush upon the commutator or by reason of the commutator being dirty, either of which will allow poor contact between the brushes and commutator.

Q. 174.—What is the remedy for each of these troubles?

A.—Should the sparking at the brush points be produced by an improper or insufficient pressure of the brushes upon the commutator the trouble can be remedied by tightening up the brush spring, which is done by moving the adjustment screw to the right. Should the sparks at the brush points be produced by a dirty commutator the only remedy is to stop the dynamo and remove the dirt, cleaning the commutator with a damp cloth or piece of waste, then rubbing dry with a clean cloth.

Q. 175.—In case the sparking has been so violent as to cause some of the commutator bars to become slightly fused, or if the dirt can not be removed by scouring the bars with a piece of damp cloth or waste, what must be done to put the commutator in perfect and satisfactory condition?

A.—If the sparking at the brush points can not be stopped by cleaning the com-

mutator with a piece of damp cloth or waste, it will be necessary to clean it up with a piece of number "O" sandpaper, being careful after using the sandpaper to clean the commutator thoroughly with a damp cloth, and wipe perfectly dry.

Q. 176.—What is the cause for flat spots being produced on the surface of the commutator?

A.—They are usually produced by excessive sparking due to a piece of dirt or mica projecting at that point, though frequently when cleaning the commutator with sandpaper the one making the repair will press the sandpaper against the bars of the commutator with his fingers when he sees a dark spot and seems unable to remove it in any other manner. This must be avoided, as it will produce flat spots.

Q. 177.—What usually causes sparking of the brushes when the new style brush holder is used?

A.—A dirty commutator.

Q. 178.—Is it ever advisable to use emery paper on the commutator, and if not, why?

A.—No, for the reason that small particles of emery will become embedded in the metallic bars of the commutator and when the dynamo is started in operation these small particles of emery will cut and scratch the brush and commutator.

making commutation very poor, and the commutator will be rendered almost if not entirely useless.

Q. 179.—When the contact is perfect between the commutator and brushes, what is their appearance?

A.—The brushes are worn to a smooth and polished bearing and the commutator takes on a high, dark cherry polish, a condition that is very much desired for a perfect working dynamo.

Q. 180.—What are the wires called that are used for conducting the current to and from the arc lamps?

A.—The main or lead wires.

Q. 181.—In what manner are these main or lead wires connected to the dynamo and lamp?

A.—These wires are connected to the dynamo by means of binding posts held by the bottom brush holder; they are connected to the lamp by binding posts of similar form, secured to the lamp column.

Q. 182.—Is it necessary for the operation of this device for these binding posts to be perfectly insulated from their connections?

A.—Yes. All of these binding posts must be insulated from the point of suspension, except the one at the dynamo, which is not connected to the field coil.

Q. 183.—What is the difference between the two binding posts?

A.—These posts are known as the positive and negative binding posts. The positive binding post is provided with a much larger hole for the wire to enter than the negative binding post.

Q. 184.—Are the wires used for conducting the currents to and from the lamp the same size?

A.—Yes, of equal size.

Q. 185.—Explain why the holes made in the positive and negative binding posts are of unequal diameter.

A.—This dynamo is so designed and constructed that the current which it generates flows in one direction, in one wire. The wire used for conducting the current from the dynamo to the lamp is known as the positive wire, and the wire used for returning the current from the lamp to the dynamo is called the negative wire. It can be seen that, if we desire to have the current enter the lamp on a certain side and the wire connections are changed in such a manner that the current enters the lamp from the opposite direction, trouble would result. A ferrule is put on each end of the positive wire or both ends of this positive wire are doubled or bent back so that it can not be made to enter the negative post.

thereby disarranging the direction of the flow of current through the lamp. Hence the necessity of the large hole in the positive binding post.

Q. 186.—How will the current pass through the lamp when the wires are connected up properly?

A.—The current always flows out of one particular brush at the dynamo into and through the circuit, returning to the armature through the medium of the other brush. If the wires are connected to the lamp and dynamo in a proper manner the current flows out of *one* of the brushes through the field coils and then into the *positive* wire (which must be connected to the binding posts at both dynamo and lamp having the large hole for the wire to enter), from the positive binding post at the lamp, through the wire to the top bracket of the lamp, into and through the top carbon, from there into the copper electrode, then through the wire that is attached to the clamp for the electrode holder, into the solenoid coil to the negative binding post and into the negative main or lead wire which is secured to the same post, then to the negative binding post at the dynamo, where the current enters the armature through the opposite brush.

Q. 187.—What forms a closed circuit?

A.—When a circuit forms a continuous conducting path it is said to be closed.

Q. 188.—When is a circuit open?

A.—When a discontinuity occurs in such a manner that an electric current can not flow an open circuit is formed.

Q. 189.—How is the amount of voltage produced by the dynamo determined?

A.—The amount of current and voltage produced is determined by the speed at which the armature revolves. Or, in other words, the current and voltage are proportional to the speed of the armature.

Q. 190.—What will occur when the main bushing is neglected until it becomes so badly worn that the armature in rotating may strike the pole pieces?

A.—A short circuit will be produced across the armature discs by the pole pieces. This would act as a brake on the armature, which would prevent a free and high speed and in a short time would burn the insulation from the armature coils.

Q. 191.—Why is it that the armature chamber is not made large enough that, no matter how badly the bushing might be worn, the armature would be unable to strike the pole pieces?

A.—The armature chamber is designed and intended to be of a size just suffi-

cient to allow for the mechanical rotation of the armature and for a reasonable wear to the bushings without the armature coming in contact with the pole pieces, and as the magnetic lines of force are attracted to this armature by the repelling of like and unlike forces in the pole pieces it would not be practicable to increase the magnetic step from the pole pieces to the armature to too great a length.

Q. 192.—What are the pole pieces, field cores and armature core made of?

A.—They are made of iron.

Q. 193.—Why is it not practicable to use steel instead of iron for these cores?

A.—Steel when once magnetized retains its magnetism permanently, while iron can not be permanently magnetized and only retains its magnetism while an electric current circulates in the copper wires that are wound upon its surface. The strength of the armature as an electro-magnet is proportional to the amount of current that is drawn from the armature, and as the length of the arc between the carbon points determines the amount of current that is drawn from the armature, since it is well known that the length of the arc varies as the carbon burns away, it can readily be seen that the strength of the magnets must

also vary; hence it would not be possible to use steel for the armature or field cores.

Q. 194.—Would it be possible to produce an electric dynamo without using iron as a magnet?

A.—An electric dynamo could not be produced without the use of iron as a magnet for reasons explained in the answer to the preceding question.

Q. 195.—How is it that a dynamo will "excite itself" and build up, if it is true that iron does not permanently retain its magnetism?

A.—Iron does not retain its magnetism after a current of electricity ceases to flow in the wires that are wound upon its surface, yet a small flux is retained in the iron. This is called residual magnetism, and on account of this a weak magnetic field is always present in the pole pieces and field magnets, and when the armature is started in motion the few lines of force contained in this magnetic field are quickly increased until eventually for a given speed of rotation of the armature the magnetism and voltage will reach a maximum value beyond which it will not increase without a further increase of the armature speed.

Q. 196.—Then it must be understood that the speed at which the armature ro-

tates determines the amount of current and voltage produced in order to successfully operate the dynamo?

A.—Yes. It must be understood that an increase in the speed of the armature means an increased output of current, while a decrease in the armature speed will cause a corresponding decrease in the output of current.

Q. 197.—When this dynamo is operated at a speed of 1,800 revolutions per minute, what is the voltage produced?

A.—Thirty-five volts.

Q. 198.—Is the rate of flow of current, which is measured in amperes, affected by the variations of the armature speed?

A.—Yes.

Q. 199.—How many amperes of current will flow when the dynamo is operated at a speed of 1,800 revolutions per minute?

A.—Twenty-three amperes of current will flow.

Q. 200.—With this low voltage, only thirty-five volts, is it dangerous to handle the lamp and wires or to touch the brush holders?

A.—No, it is not dangerous to handle the lamp or wires, for the reason that the resistance of the body is far too great for this low voltage to force a current through.

Q. 201.—In case a short circuit occurs in this device the voltage will, of course, run up much higher; would it then be found dangerous to handle any part of the equipment?

A.—When a short circuit occurs the voltage is increased, until it may make itself forcibly known if one should come in contact with the wires or metallic substance which would be carrying a heavy current, though there is really no possible chance of an injury to anyone.

Q. 202.—Is it possible to so adjust the mechanism of the arc lamp that a heavier current than thirty-five volts will be carried?

A.—Yes, for the reason that the length of the arc determines the amount of current that will circulate within the coils. Greater resistance is offered to the passage of the current from one carbon point to the other when the arc is long than when it is short, and if the tension spring in the lamp is offering more resistance than is necessary against the action of the solenoid this resistance will necessarily produce a short arc which will offer less resistance to the passage of the current across from one carbon point to the other, thereby allowing the voltage to run up a little higher.

Q. 203.—What will be the effect upon

the operation of the dynamo and the efficiency of the lamp if the tension spring is run too tight?

A.—This tightening of the tension spring too tight will allow a heavy current to be carried in the coils, and will slow down the speed and produce a poor and unsatisfactory light.

Q. 204.—Mention the duties of the tension spring.

A.—This tension spring serves, first, to bring the levers and clutch in such a position that the two carbon points come together, thereby closing or forming the circuit, and, second, it serves to prevent the magnetism of the solenoid from pulling the iron magnet down too far, thereby separating the carbons so far that a break would occur in the circuit, when the light would go out.

Q. 205.—What tension should be given this spring?

A.—When this spring is adjusted so that the light will flicker or flash just a little when the locomotive is at rest the tension is correct, and you will then be securing all the light possible at a given speed of the armature and the light will burn brightly and steadily when the locomotive is running.

Q. 206.—When two carbons are used, how is it possible for the engineer to de-

termine which of the carbons the current is entering first, or in which direction the current is passing through the lamp?

A.—By noting which carbon point heats up first you can determine the direction in which the current is flowing through the lamp. The point of carbon that the current enters first, thus heating it, is the positive carbon.

Q. 207.—Why is the point of the positive carbon heated up first?

A.—The temperature of an electric arc is about 7,000 degrees F. This arc or crater is only found in what is known as the positive carbon, the carbon which a direct electric current enters first. Since this high degree of temperature is produced in the point of one carbon and not in the point of the other, it can easily be seen that this positive point would heat up before the negative point.

Q. 208.—Which carbon should be the positive when two carbons are used, and why?

A.—The top carbon must always be used as the positive point for the following reason: When a lower carbon is used with this device for the negative point it burns away only about half as fast as the top or positive carbon, and the lower carbon holder will only accommodate a carbon of sufficient length

to insure its outliving the top carbon. Were the wires so connected that the current could be introduced through the bottom carbon first this short carbon would not be of sufficient length to burn more than about four hours, and since the top carbon feeds down by gravity, if the lower carbon was not replaced before it was consumed, if used as the positive, the lower carbon holder would be destroyed because the top carbon would continue to feed down against the lower holder, maintaining the arc against the holder and thus destroying it.

Q. 209.—In what manner is an electric spark or light produced?

A.—Opposition, or resistance, when placed in the path of an electric current will produce an electric spark or light.

Q. 210.—Give an example of resistance placed in the path of an electric current.

A.—When a current of electricity, in passing through a wire, reaches a place where it can not pass easily, as would be the case if a large wire was suddenly reduced to a very small one, because of the high resistance offered by the small wire, heat and light are at once produced. A striking illustration of this law of resistance is the incandescent lamp.

Q. 211.—What is it that prevents the fine wire which is placed in the incan-

descent globe, for the current to pass through, from being burned up?

A.—The fine wire in the incandescent globe does not burn up for the reason that the globe has been completely exhausted of air and contains a perfect vacuum.

Q. 212.—In what manner is the arc produced?

A.—To produce the arc, the points of the positive and negative carbons are brought in contact with each other until a current is established and then they are drawn a short distance apart by the mechanism of the lamp.

Q. 213.—Explain the operating mechanism of this lamp and how the arc is produced and maintained.

A.—The mechanism of this lamp, which causes it to produce and maintain the arc, is composed of a solenoid and magnet which are attached to the levers and clutch. When the current is flowing in the coils and the carbons are burning away, the strength of the magnet grows weaker as the arc grows longer, and at a certain point this magnet will become weak enough to release the clutch which is holding the carbon and allow the latter to drop of its own weight toward the electrode; before the carbon can drop to the electrode, however, the

current through the magnet is again changed and strengthened, and the downward motion of the carbon is arrested.

Q. 214.—For what length of time should the top or positive carbon burn?

A.—When the speed of the dynamo is about 1,800 revolutions per minute, which is maximum speed, the positive carbon should burn from eight to nine hours.

Q. 215.—Where would you look for the cause of the trouble if the positive carbon, which should burn from eight to nine hours, is consumed in from six to seven hours?

A.—It will be found almost without exception that the speed of the armature is excessively high, though in rare cases a carbon may be found that is very soft, and it will burn more rapidly than the hard ones.

Q. 216.—Should the edge of the clutch become worn until it is smooth and round, what will result?

A.—If the edge of the clutch was smooth and round, instead of sharp, it would be difficult to raise the carbon away from the point of the copper electrode at any time, and when the speed of the locomotive was high there would be nothing to prevent the top carbon from being jarred down to the point of the copper electrode (or lower carbon), which

would cause a short circuit through the lamp.

Q. 217.—When the edges of the clutch are no longer sharp enough to hold the carbon firmly, and the clutch had been made to drop the carbon by the jar and shake of the locomotive caused by high speed, will the clutch be able to again lift the carbon away from the point of the electrode and establish the arc when the speed of the locomotive has been decreased?

A.—It could not, for if the top carbon is jarred down to the point of the lower carbon or copper electrode by the speed of the locomotive, the clutch could not again engage the carbon for the reason that the magnet yoke would then be pulled down as far as it could travel, or against the lower lug on the lamp column.

Q. 218.—What will be the effect upon the light produced if the tension of clutch spring *91a* should become weakened?

A.—It will allow the heel of the clutch to be jarred up when the speed of the locomotive is high, and the same trouble and effect will be produced as is experienced when the edge of the clutch is worn round and smooth.

Q. 219.—What would be the effect if the tension of this clutch spring *91a* was too strong?

A.—If the tension of this spring, which holds the heel of the clutch down, was too heavy, it would require a stronger current circulating in the solenoid in order to produce strength enough to overcome this opposition and separate the carbon points than if the tension is normal, and thus excessive heating of the coils will result and eventually the insulations will be damaged.

Q. 220.—What will cause the light to go out when the locomotive is at rest?

A.—There are three causes for the light going out when the locomotive is stopped at a station, etc. First, if the tension of spring *93* is too weak the light will go out or will flash badly when the locomotive is at rest, because this spring will not have tension sufficient to pull the levers down and release the carbon. Second, unless the carbon used is straight and round it will be held up in the clutch and the light will go out. Third, a dirty, sticky dash-pot plunger which will hold the lever down and the clutch up is the most common cause for the light going out when the engine is stopped.

Q. 221.—How is the engineer to distinguish between the three named troubles?

A.—If the trouble is caused by too weak a tension on spring *93*, the light

will flash or flicker very badly at all times, when the speed of the locomotive is high or when the speed is low. To distinguish between a dirty uash-pot pluger and an imperfect carbon, place the fingers on the governor yoke and move same down until the lost motion is taken up between the levers and the clutch point is brought up against the carbon, and if the clutch point and rod fall quickly to point of rest when the fingers are removed from the yoke, the trouble lies in the carbon; otherwise it is caused by a dirty dash-pot plunger and can be overcome by cleaning.

Q. 222.—Is it advisable to use oil in the dash pot?

A.—It is never advisable nor permissible to put oil in the dash pot except for the purpose of cleaning, and if used for that purpose the dash pot and plunger must be wiped and cleaned thoroughly, or untıı absolutely free from oil.

Q. 223.—For what purpose is the dash pot used?

A.—The dash pot is used on this lamp for the same purpose that the dash pot is used with the Corliss engine—simply for the purpose of offering a cushion for the levers. On account of the speed at which the electric current enters the solenoid, if the dash pot was not used and

connected with the levers in such a manner as to offer *resistance* to the action of the solenoid on the levers and carbon, the levers and carbon would be made to jump, causing the arc to flash, and in a short time one of the levers would be broken.

Q. 224.—Is there any other cause for the light going out when the locomotive is brought to rest?

A.—Yes. If the copper contact brush, which is attached to the top carbon clamp, was pulled out until it would bear with too much pressure against the guide *100* of the top carbon-holder, when the engine was stopped it would hold the carbon up and the light would go out.

Q. 225.—What might result if the copper contact brush did not touch the guide *100?*

A.—The copper contact brush is attached to the top carbon holder because it will allow an easy and free passage of current from the top carbon holder into the carbon as it feeds down and is consumed. If there was no other contact between the guide *100* and the top carbon clamp than the contact between the flange of the carbon clamp and the guide, the irregular motion of the locomotive by shaking the carbon around would offer a very poor path for the current to pass

through from the guide to the carbon, and would produce sparks at this point which would blister or burn the guide and carbon clamp until one or both would be rendered useless.

Q. 226.—What distance should the magnet yoke travel down before all of the lost motion between the levers and clutch is taken up and the clutch has been brought up against the carbon ready to separate the carbon points?

A.—The magnet yoke should travel to a position half way between the two lugs found on the lamp column, *51½*, before the clutch is brought to a position where it will separate the points of the carbons.

Q. 227.—If the magnet yoke is tight against the top lug on the lamp column and there is no lost motion between the levers and clutch, what will result?

A.—It is very probable that the carbon might not feed down and the levers would jump, because the iron magnet, *64*, would be held too far out of the solenoid and the magnet could not get sufficient hold on the iron to sustain it.

Q. 228.—What might be the result if the magnet yoke was allowed to travel down farther than half way between the lugs on the lamp column before the carbon was engaged?

A.—Should the magnet yoke be allowed to travel down farther than half way between these two lugs on the lamp column before the lost motion in the levers was taken up, when the carbon was raised, the yoke would be brought down against the bottom lug before the carbon could be lifted high enough to produce a good arc and light.

Q. 229.—Give the reason for suspending the iron magnet, *64*, part way out of center of the solenoid.

A.—The action of the solenoid and its magnetization tends to pull this iron magnet down and into the center of the solenoid. This iron magnet is attracted to the levers that engage the carbon, and if suspended in the center of the solenoid it could not do any work for us, as it would be held in this position as long as an electric current was circulating in the solenoid and hence could not operate the levers. For that reason the iron magnet is suspended at a position far enough out of, and above, the center of the solenoid so that the magnetism of the solenoid will produce a downward motion on the levers and iron magnet, *64*, raising the carbon and so producing the light.

Q. 230.—What would be the result if this iron magnet was suspended too far above the center of the solenoid?

A.—It would be impossible to adjust the lamp in such a manner as to prevent the levers from "jumping" when the light was started if the iron magnet, *64*, was held too far above the center of the solenoid.

Q. 231.—Give the correct position for this iron magnet in the solenoid.

A.—The correct position of the iron magnet in the solenoid is secured in the following manner: When the magnet yoke is pulled down against the bottom lug on the lamp column it should be ¾ of an inch from the bottom of the solenoid to the bottom of the iron magnet.

Q. 232.—If the speed of the armature becomes excessive when the copper electrode is used, what will result?

A.—It would cause the copper electrode to fuse.

Q. 233.—Why will the copper electrode fuse when the speed of the armature is very high?

A.—When an electric arc is produced between two carbon points, such as is produced between the carbon and the copper electrode when the lamp is in action, small particles of carbon are torn away from the end of the carbon and become volatilized. A part of these small particles of carbon are deposited on the point of the copper electrode, and the cur-

rent passing from the carbon point to the electrode flows through these small particles of carbon which have been volatilized by the heat of the arc. As long as these particles of carbon are deposited on the point of the copper electrode the electrode will not fuse, because these particles of carbon are to the electrode what the water is to the crown sheet of the locomotive boiler. But when an armature speed is allowed that will bring the temperature of the arc high enough these small particles of carbon will be burned up before they can fall to the point of the electrode and, like the crown sheet when the water is off of it, the protection of the electrode from the intense heat of the arc (which is now more than 7,000 degrees F.) is gone, and the copper, which melts at a very much lower temperature, will have been fused.

Q. 234.—How will the engineer know when the armature has attained a speed at which the copper electrode will be fused?

A.—By the fact that, when copper is fused, a shaft of green light will be thrown off instead of a shaft of white light.

Q. 235.—Is there any possible chance for the engineer to be mistaken about this green light?

A.—No, for there is nothing quite so green as this shaft of light when the copper electrode is fusing.

Q. 236.—What steps must immediately be taken to remedy the trouble and prevent further damage when this shaft of green light is produced?

A.—As soon as it is observed by the engineer he must immediately reduce the speed of the armature by closing in on the throttle valve of the steam turbine. until a shaft of white light is produced.

Q. 237.—In what other way is a green light produced than by excessive speed of the armature fusing the copper electrode?

A.—If, through carelessness, the *positive* wire was connected to the *negative* binding post, either at the dynamo or the lamp, the current would enter the copper electrode first and a green light would be produced, because the arc is always produced in the point which the current enters first, and in entering the copper electrode first the copper would be fused.

Q. 238.—What must be done to remedy the trouble when crossed wires are responsible for the production of the green light?

A.—The wire connections at the binding posts, either at the dynamo or the lamp, must be changed in order to in-

troduce the current into the top carbon first and produce the white light.

Q. 239.—How will the engineer know whether the green light is caused by excessive speed of the armature or by crossed wires?

A.—In case the light comes up white and then turns to green the engineer may know that it is caused by high speed of the armature, while if the light is green the instant it appears the cause of the trouble is to be found in crossed wires.

Q. 240.—What should the engineer examine with care in order to know that his electric headlight is in good working condition before he starts out on a trip?

A.—In order to know that his electric headlight is in good working condition the engineer must follow these instructions to the letter: First, the water of condensation should be drained from the oil cellar in the engine cap and this bearing should be oiled with cylinder oil. Second, see if the loose ring which is suspended by the shaft and in the oil cellar of the main bearing touches the oil, and if it does not enough engine oil should be introduced into this cellar so that this oil ring will touch. Third, see that the commutator is mechanically clean and that the mica strips between the commutator bars are below the sur-

face of the bars. Fourth, see that the brushes are perfectly free in the holders, are not stuck or even tight, and that they have a good bearing. Fifth, be sure to note if both of the main wires are held securely in the binding posts, and that the binding post screws are tight against the wires both at the dynamo and the lamp. Sixth, be careful to examine where the wires may enter or leave the pipes or the hand railing, the headlight case and the cab, and know without doubt that the insulation is in good condition on all wires both in and out of the cab. Seventh, see that the carbon in the lamp is of sufficient length to make the trip, and that the clutch will lift the carbon at least ¼ of an inch from the point of the copper electrode. Eighth, be careful to note if the point of the copper electrode is clean and that it is pointed up with ⅛ of an inch surface on the point. Ninth, see that the copper electrode is not stuck in the holder. Tenth, be sure that the point of the copper electrode lines up true under the carbon.

Q. 241.—If the scale is left upon the point of the copper electrode and not cleaned off as directed, what will be the effect upon the operation of the dynamo?

A.—When the steam is turned on to start the dynamo in operation in almost

every instance it will be found that the dynamo will not "build up," for the reason that this scale will offer too great a resistance for the low current to pass through to complete the circuit and build up the magnetism.

Q. 242.—Is it only necessary to remove the scale from the *point* of the copper electrode?

A.—The scale should be cleaned from the entire copper electrode each time the point of this electrode is cleaned off.

Q. 243.—What will result if the copper electrode is neglected and this scale allowed to form and remain upon it?

A.—The electrode will become stuck fast in the holder in a very short time and the scale between the copper electrode and the holder will completely insulate the electrode from the holder, and it will not be possible to establish a circuit until the electrode is removed from the holder and the scale all cleaned off.

Q. 244.—When upon examination we find that the commutator is clean and copper electrode and holder are free from scale, yet the dynamo refuses to build up, what must be done in order to secure the operation of the dynamo?

A.—When the dynamo refuses to build up in spite of the fact that our examination shows us that the commutator and

copper electrode are clean and in good condition, we can usually establish the circuit and bring up the light by holding a piece of carbon against both binding posts for a few seconds, either at the dynamo or the lamp.

Q. 245.—Why does the dynamo refuse to build up at such times without bridging across the binding posts with a piece of carbon, and what is the reason for its building up when the carbon is used?

A.—The dynamo will not build up in such cases for the reason that the resistance offered at the points of the carbons is too great for the weak current to pass through, but when you place the carbon across the binding posts you cut out the point of great resistance or poor contact and form a good and direct path across from one binding post to the other, thus allowing the fields to build up at once, and when the carbon is removed from the binding posts the current will be found to be strong enough to pass through the point of great resistance or poor contact at the carbon points, and the light will come up.

Q. 246.—At what time is the strength of the solenoid greatest?

A.—When the arc is short the strength of the solenoid is greater than at any other time, for the reason that

when the arc is short there is less resistance offered to the passage of current from one carbon point to the other and there is more current circulating in the coils.

Q. 247.—Is it very important that the engineer should know that the end of the lever, *59*, is under the clutch rod weight, *78a*?

A.—The end of the lever, *59*, must be under the clutch rod weight, *78a*, because if it was not the carbon could not be lifted and the lamp could not operate.

Q. 248.—Why is it important to know that the thumb nut, *79*, which secures the top carbon holder in the top bracket, *57*, is tight?

A.—If the thumb nut, *79*, should work loose it would allow the top carbon holder to work loose and the carbon to drop by the point of the copper electrode, and a short circuit would result. Hence it is important to know that this thumb nut, *79*, is tightened up firmly.

Q. 249.—What are we to do after drawing carbons from the store room to insure their feeding freely through the clutch when placed in the lamp?

A.—After drawing carbons from the store room we should remove the top carbon holder from the lamp and should try each of the carbons through the holder

in order to ascertain if they will feed freely through the clutch when placed in the lamp.

Q. 250.—If we find a carbon that will not pass freely through the clutch should we try to use it?

A.—If we find a carbon that will not pass freely through the clutch it must be turned until a position is found where it will pass through. If it is found that this particular carbon will not pass through the clutch in any position without friction it should be thrown away and another one substituted in its place.

Q. 251.—What is the object in finishing up the point of the copper electrode with a surface of ⅛ of an inch?

A.—No shadows are produced near the locomotive when the copper electrode is finished up with a surface of ⅛ of an inch, and it is possible also to secure a better focus of the lamp, for the reason that with the ⅛ of an inch surface a long arc is produced instead of a thin, flat arc, such as would be produced if the copper electrode was given ½ of an inch surface.

Q. 252.—What must be done if the points of the carbon and the copper electrode do not line up true?

A.—When it is found that the points of the carbon and the copper electrode

do not line up true, either the electrode holder or the top bracket which suspends the top carbon holder must be sprung until the carbon and copper electrode are brought in line with each other.

Q. 253.—Which holder is usually bent in order to cause the points of the carbon and the copper electrode to line up?

A.—Ordinarily it will be found that the lower, or copper, electrode holder is the one that is out of alignment, and should be bent to bring it under the carbon.

Q. 254.—Is there not some danger of breaking this electrode holder by bending in order to make it line up under the carbon?

A.—For the reason that the electrode holder is made of brass and will bend very readily there is small danger of breaking it when bending to line up under the carbon.

Q. 255.—In case your electric headlight equipment has been working perfectly as you ran along between stations, but suddenly your light began to "jump and flash" very badly, what would in all probability cause the trouble?

A.—The flashing of an electric arc or light is caused by an interruption in the flow of the current. Should you meet with this trouble, investigation will

prove that one of the wires is loose at the connection or that the wires have been allowed to swing or chafe at some point, thus causing the insulation to be chafed or worn off, and the wires are striking against some metallic substance, thus momentarily breaking the circuit and preventing the current from passing through the lamp and causing both the arc and cab lamps to flash.

Q. 256.—Is it essential that no portion of the lamp shall come in contact with the reflector?

A.—It is very essential, as such a condition will cause a short circuit through the lamp and the light will not burn.

Q. 257.—In case your light suddenly goes out while running between stations or at any time, what steps should be taken to prevent any further damage being done the equipment?

A.—In case the light fails and you can not look at once for the trouble, in order to prevent any further damage being done the equipment the steam to the turbine engine must be turned off and the dynamo stopped until such time as you have an opportunity to locate the trouble.

Q. 258.—Can an engineer distinguish between a short circuit and an open circuit by the sound of the exhaust from the turbine engine?

A.—The engineer will experience no more difficulty in distinguishing between a short and an open circuit by the sound of the exhaust from the turbine engine than in determining where his engine is "lame" by the sound of the exhaust from the locomotive.

Q. 259.—What effect will a short circuit have upon the sound of the exhaust from the turbine engine?

A.—It will be remembered that a short circuit allows all of the current to flow back into the armature without dissipating its pressure, thus leaving a very heavy current present in the coils, and this would make an extra heavy load for the turbine engine to pull. This heavy load would tend to slow the engine down, and as the speed of the turbine wheel was decreased by the heavy load the ends of the governor weights would be pulled down toward the shaft by the governor springs, and the governor valve would be opened wide and so allow a much greater volume of steam to pass through the wheel, thus causing a heavy, laboring sound, and one that is heard at no other time.

Q. 260.—How will the sound of the exhaust from the turbine engine be affected by an open circuit?

A.—In case of an open circuit, that is,

if we have a broken wire or the carbon is stuck up in the clutch or anything occurring that will break the circuit, the dynamo will have no work to do and no load will be thrown upon the turbine engine. The engine being relieved of all load except that of turning the shaft and armature, will, of course, run very rapidly, and in doing so the governor, which is of the centrifugal form, will force the governor valve into the seat of the steam supply to the governor stand, and very little steam will be allowed to pass from the exhaust pipe, and the noise made by the escaping steam will be very light.

Q. 261.—In what part of the equipment do short circuits usually occur?

A.—Short circuits in this device are found almost without exception in the wires leading to the cab lights or in the wires leading from the dynamo to the lamp.

Q. 262.—How can a short circuit be located?

A.—In order to locate a short circuit in this equipment the first thing to be done is to start the dynamo with a good throttle opening and remove one of the main wires from the binding post at the dynamo. If after this is done the machine continues to run slow the trouble

is to be found in the cab circuit. Disconnect one of the cab wires and return the main wire to the binding post at the dynamo and the arc lamp will burn. If you have no time now to find cause and make repair you can locate the cab trouble at your leisure.

Q. 263.—Where will you look next for the trouble if the speed of the dynamo increases when one of the main wires is removed from the binding post at the dynamo?

A.—In case the speed of the dynamo instantly increases when one of the main wires is removed from the binding post at the dynamo the trouble is not to be found in the engine, the dynamo or the cab circuit, but farther on toward the lamp. Return the main wire to the binding post at the dynamo and go to the lamp to make the next test. Remove one of the main wires from either binding post at the lamp, and unless the speed of the dynamo increases instantly the short circuit will be found in the wires between the dynamo and the lamp, where it will be found that the insulation is off both wires and the wires are in contact with each other, either directly or through the medium of the hand railing or conducting pipe.

Q. 264.—Where would you look for the

trouble if the speed of the dynamo should increase when the wire is removed from the binding post at the lamp?

A.—The trouble will be found *in the lamp*, where it will be seen upon examination that the thumb nut used to secure the top carbon holder to the bracket has become loosened and so allowed the point of the carbon to pass by the point of the copper electrode, or it will be found that the carbon is stuck fast in the clutch and against the point of the copper electrode.

Q. 265.—Where is the trouble to be found if the dynamo continues to run slow and labor heavily after the wire has been removed from the binding post at the dynamo and the cab circuit is also cut out?

A.—In case the dynamo runs slow and labors heavily after the wire has been removed from the binding post at the brush holder and the cab circuit has been cut out, the trouble is to be found either in the engine or the dynamo.

Q. 266.—How can we remedy the trouble if it is found to be in the engine?

A.—If the engine is responsible for the low speed and heavy load, the trouble can be overcome by oiling the bearing and adjusting the end thrust to a movement of 1-32 of an inch.

Q. 267.—Where is the trouble to be found if the engine continues to labor heavily after the bearings have been properly lubricated and the end thrust adjusted?

A.—The trouble will be found to be a short circuit in the armature or field coils.

Q. 268.—What would cause a short circuit in the armature or field coils?

A.—This is not likely to occur except by *first* running the equipment when there is a short circuit in either the cab or main wires or the lamp. Such abuses as carrying a heavy current in the wires would ultimately charr the insulation on the armature coils or the field wires until the insulation would no longer be a good insulator, and the current would then leak through from layer to layer. This is known as a burned out armature or coil.

Q. 269.—If the governor valves were stuck shut would we be likely to mistake this condition for a short circuit?

A.—No: we could not make that mistake, because while the speed of the dynamo would be very low if the governor valves were stuck shut, yet there would be very little steam passing out of the exhaust pipe, and practically no noise would be made.

Q. 270.—How can the exact point of trouble in an open circuit be located?

A.—When we have an open circuit, which means no circuit (as no current is circulating in the coils), it will be found necessary to close the circuit in order to find the break. First try to locate the trouble by testing at the dynamo. This is done by placing a carbon across from one binding post to the other; if a flash results, the dynamo is all right and you must look farther on toward the lamp for the break. Go to the lamp and bridge across in the same manner from one binding post to the other with a piece of carbon. If a flash is not produced, the break will be found in the wires between the dynamo and the lamp.

Q. 271.—Where will we find the trouble if we get a flash when bridging across the binding posts at the lamp with a piece of carbon?

A.—The trouble will be found in the lamp if a flash is produced at the binding posts at the lamp by bridging across same with a piece of carbon. All that will then be required to produce a light is to clean all the scale from the copper electrode, not only the point of the electrode but the entire body, and to put in a new carbon.

Q. 272.—Where is the trouble to be

found if a flash does not result when the carbon is placed across the binding posts at the dynamo?

A.—The trouble will be found in the dynamo if no flash is seen when the binding posts at the dynamo are bridged with a piece of carbon.

Q. 273.—In case no flash results at this point what should be done in order to locate the trouble and make repairs?

A.—If no flash results at the binding posts at the dynamo see to it that the commutator is perfectly clean, that the connections of the field wires are secure and that the brushes are free in the holders and have proper bearing on the commutator.

Q. 274.—Where would you look for the trouble in case the commutator, brushes and field connections are found to be in good order?

A.—We should look at once for a broken armature wire or field coil.

Q. 275.—Is it possible to use the armature temporarily when one of the field coils is broken without replacing the broken coil?

A.—In case one of the field coils is broken on an armature and there is not another armature at hand to replace the one in use, temporary repairs of the armature with the broken wire can be

made by soldering together at the heel the commutator bar with the broken wire and the commutator bars on each side of the broken point, thus allowing the current to pass across through the heel of the commutator bar, and so completing its circuit through the armature.

Q. 276.—What should be done if one of the main wires from the dynamo to the lamp, which has been placed within the hand railing, should break while the equipment is in service out on the road?

A.—Pull both ends of the broken wire from the hand railing and repair the break, leaving the wire outside of the hand railing for the remainder of the trip.

Q. 277.—How could temporary repair be made to such a broken wire while out on the road?

A.—In order to make temporary repair to such a broken wire strip back the insulation from the ends of the broken wire and twist the ends of the wires together securely, after which the exposed wire must be wrapped with anything available to form an insulation. A pocket handkerchief may be used.

Q. 278.—In what way will a broken cab wire affect the operation of the dynamo?

A.—A broken cab wire will merely

cause the lights in the cab to go out beyond the point where the wire is broken, and will have no effect whatever upon the operation of the dynamo or the efficiency of the headlight itself.

Q. 279.—Can a short circuit occur at any point in the lamp that has not already been mentioned?

A.—A short circuit may occur in this device at the top or at the bottom brackets of the lamp, and at the binding posts where they go through the lamp column or at the binding posts or brush holders.

Q. 280.—What will cause a short circuit to occur at the brackets of the lamp or the binding posts?

A.—An accumulation of dirt, carbon dust, etc., at the bottom bracket of the lamp might cause a short circuit, but a short circuit could not occur at the insulations around the binding posts unless the binding post had been removed and in reassembling the insulations had been injured or had not been replaced at all.

Q. 281.—Do some of the Pyle National Electric Headlights appear at times to give more light than others?

A.—Yes.

Q. 282.—Give a reason for this condition.

A.—There are several reasons for this condition. First, if the speed of one

armature was higher than the speed of another the one having the highest armature speed will in all probability have the best light, but the equipment with the best focus of the lamp with a bright and clean reflector will, without question, give the best light on the track.

Q. 283.—Does the condition of the reflector have any great influence upon the light?

A.—The condition of the reflector has a marked influence upon the light when the lamp is properly focused. It must be known that when the reflector is most highly polished the reflecting surface will absorb more or less of the light rays produced, but almost forty per cent. of the light will be lost if the reflector is in a dirty and unpolished condition.

Q. 284.—How must we proceed to get the lamp properly focused?

A.—In order to get the lamp in perfect focus, first adjust the back of the reflector so that the front edge of the reflector and the front edge of the case will be parallel. Second, adjust the lamp so that the point of the copper electrode is as near the center of the reflector as possible. Third, have the carbons as near as possible to the center of the chimney hole in the reflector. Fourth, have the engine on a piece of straight

track not less than half a mile in length and move the lamp until you secure the best results on the track.

Q. 285.—Is it possible to move the lamp in all directions to secure a focus?

A.—Yes. The base of the lamp is provided with square holes through which the bolts are passed, and these holes are large enough to allow the lamp to be moved in any direction when focusing.

Q. 286.—How is the proper vertical focus on the track secured?

A.—In order to secure the proper vertical focus on the track, either to have the light strike the track far ahead or close to the locomotive, loosen the set screw, *74*, on the side of the lamp column, and by turning the adjusting screw, *98*, you can raise or lower the lamp, thereby throwing the light on the track where desired.

Q. 287.—Can we move the lamp sideways?

A.—This lamp may be moved sideways, backward and forward. In order to do this loosen the hand nuts, *54*, when the lamp can be moved freely.

Q. 288.—What must be done after the lamp is properly focused?

A.—*All screws must be tightened* after the lamp is properly focused, as there will be no occasion to change it again.

Q. 289.—In what manner is the back of the reflector supported?

A.—An adjustable step supports the back of the reflector. This adjustable step is provided with a screw for the purpose of raising or lowering, so that the entire volume of light will come from the reflector in parallel lines.

Q. 290.—In what way should the light be reflected upon the track?

A.—In parallel rays and in the smallest possible space.

Q. 291.—What must be done in order to lower the light on the track?

A.—Raise the lamp to lower the light on the track.

Q. 292.—What must be done to raise the light on the track?

A.—Lower the lamp in order to raise the light on the track.

Q. 293.—Is the lamp properly focused if the light throws any shadows?

A.—The lamp is not properly focused if it throws any shadows, as the light rays should be concentrated or drawn together, when there will be no shadows.

Q. 294.—What should be done if the light does not strike the center of the track, yet otherwise the lamp is in perfect focus?

A.—In case the lamp is properly focused, that is, if all of the light rays

leave the reflector in parallel lines and in a small pencil-like shaft, yet do not strike the center of the track, shift the entire case on the base board, but do not change the focus. The trouble is caused by the reflector case not being straight and parallel with the boiler.

Q. 295.—What precaution must be observed when you desire to remove the reflector from the case in order to clean and polish the reflector?

A.—When you desire to clean and polish the reflector, before you attempt to remove the reflector from the case always remove the top guide, *100*, by loosening the thumb nut, *79*, and take out the top carbon holder. If these instructions are not followed it will be impossible to get the reflector out and the lamp will be damaged.

Q. 296.—Is it possible to focus this lamp by measurement?

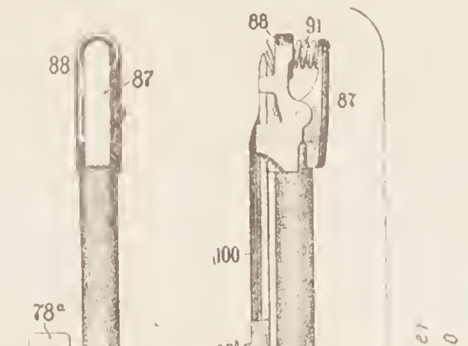
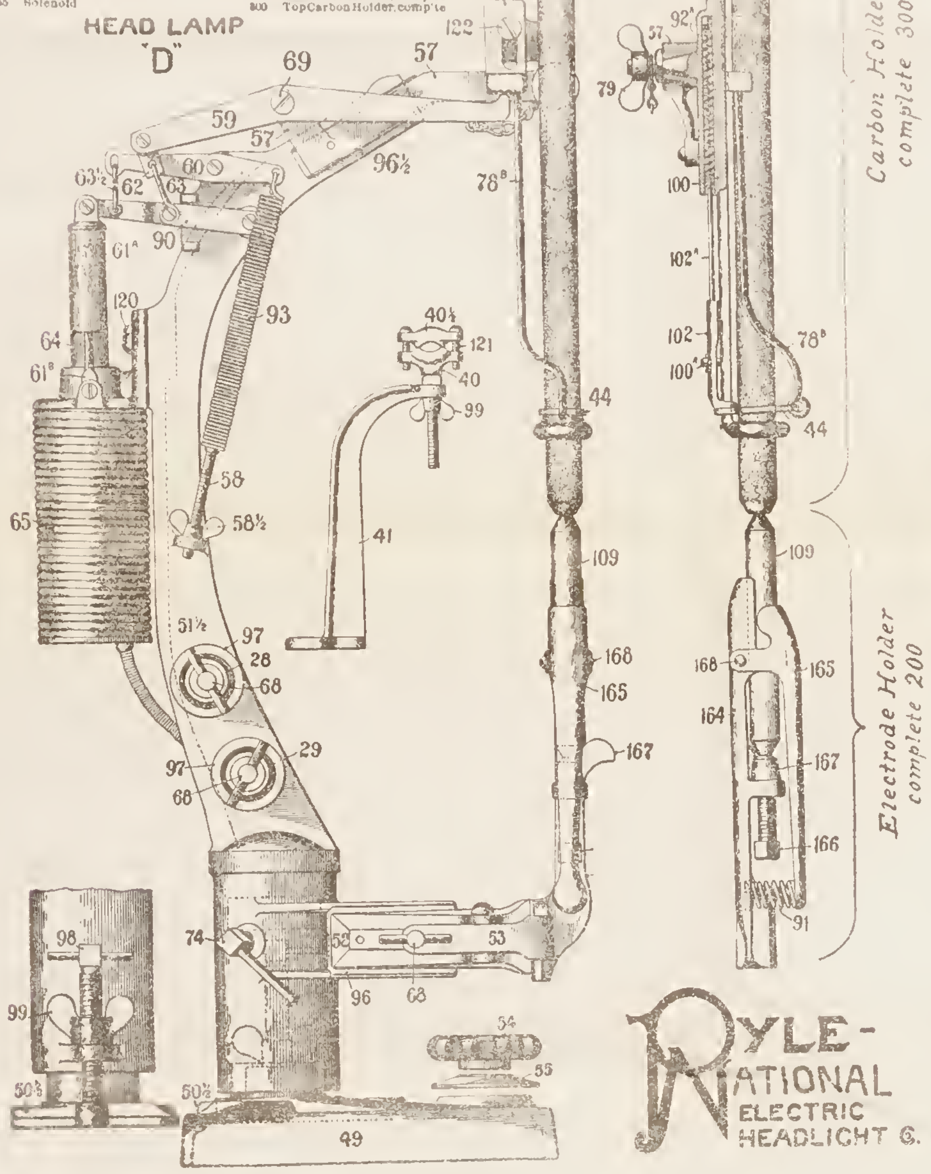
A.—This lamp can be focused by measurements in the most satisfactory manner. Following is the rule: You must know first that the reflector case sets straight and level on the arch of the locomotive, and that the front edge of the reflector is parallel with the front edge of the case. The center of the top of the copper electrode must be placed in the center of the reflector; the meas-

urements must be taken from the top of the electrode to the sides, top and bottom of the reflector, then *lower* the electrode ⅛ of an inch. If the reflector has a 16-inch face and is 8 inches deep the copper electrode must be 2⅜ inches from the back of the reflector. If the reflector has an 18-inch face and is 9 inches deep the copper electrode must be 2¼ inches from the back of the reflector. If the reflector has an 18-inch face and is 12 inches deep the copper electrode must be 1¾ inches from the back of the reflector.

Names and Numbers of Parts

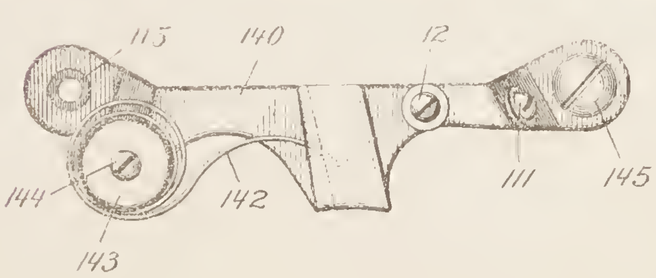
28 Binding Post, large hole
28½ Binding Post Nut
29 Binding Post, small hole
40 Reflector Clamp, bottom
40½ Reflector Clamp, top
41 Reflector Support
44 Clutch
49 Extension Base
50½ Lamp Base
51½ Lamp Column
52 Bottom, large clamp
53 Bottom, small clamp
54 Hand Nut
55 Hand Washer
57 Top Bracket
58 Spring Tension Screw
58½ Spring Tension Nut
59 Top Lever
60 Small Lever
61a Dash Pot
61b Dash Pot Plunger
62 Magnet Insulation
63 Magnet Long Link
63½ Magnet Short Link
64 Magnet
65 Solenoid
68 Binding Post Screw
69 Top Lever Screw
74 Set Screw
78a Clutch Rod Weight
78b Clutch Rod
79 Thumb Nut
87 Carbon Clamp, male
88 Carbon Clamp, female
90 Magnet Yoke
91 Carbon Holder Spring
92a Top Clutch Spring
93 Tension Spring
96 Insulation Fibre
97 Insulation Washer
98 Vertical Adjusting Screw
99 Vertical Adjusting Nut
100 Upper Carbon Holder
102 Clutch Foot
102a Clutch Foot Rod
109 Copper Electrode
120 Solenoid Screw
121 Reflector Clamp Screw
122 Clutch Weight Screw
164 Electrode Support
165 Electrode Lever
166 Electrode Set Screw
167 Electrode Lock Nut
168 Electrode Escutcheon Pin
200 Electrode Holder, comp'te
300 TopCarbonHolder,comp'te

HEAD LAMP "D"

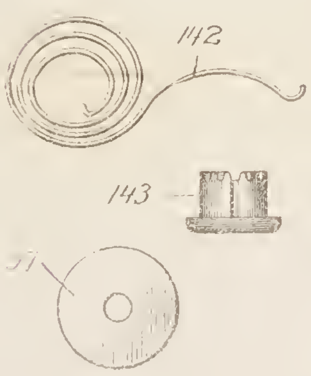
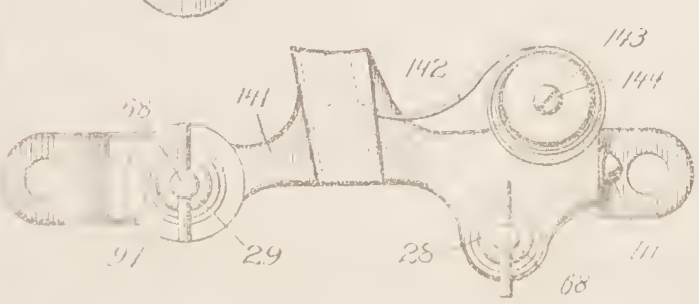
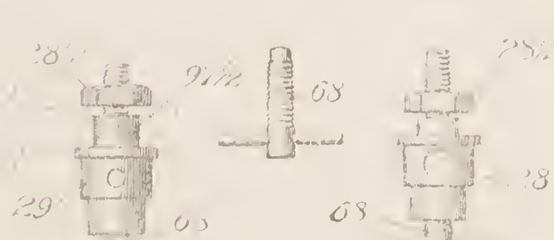



PYLE-NATIONAL ELECTRIC HEADLIGHT Co.

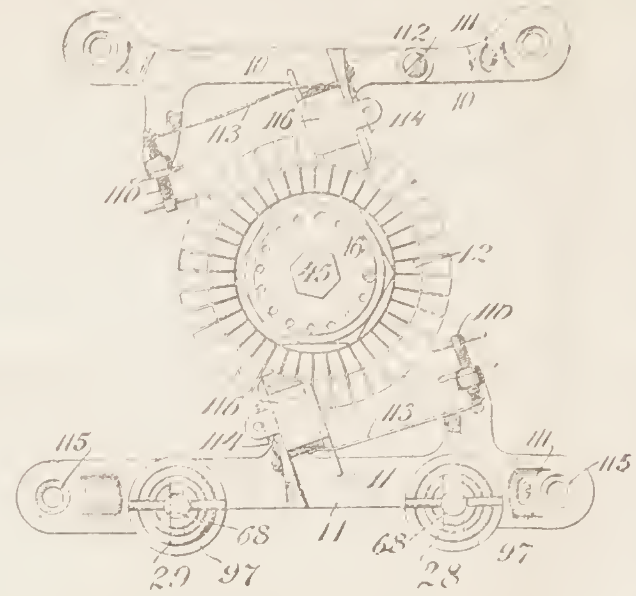
The Lamp.



28 Binding Post, large hole
28½ Binding Post Nut
29 Binding Post, small hole
68 Binding Post Screw
97 Insulation Washer
97½ Insulating Bushing
111 Incandescent Binding Screw
112 Top Field Connecting Screw
115 Bushing
140 Top Brush Holder
141 Bottom Brush Holder
142 Brush Spring
143 Brush Spring Adjuster
144 Adjuster Screw
145 Brush Holder Screw
146 **Top Brush Holder, complete**
147 **Bottom Brush Holder, complete**

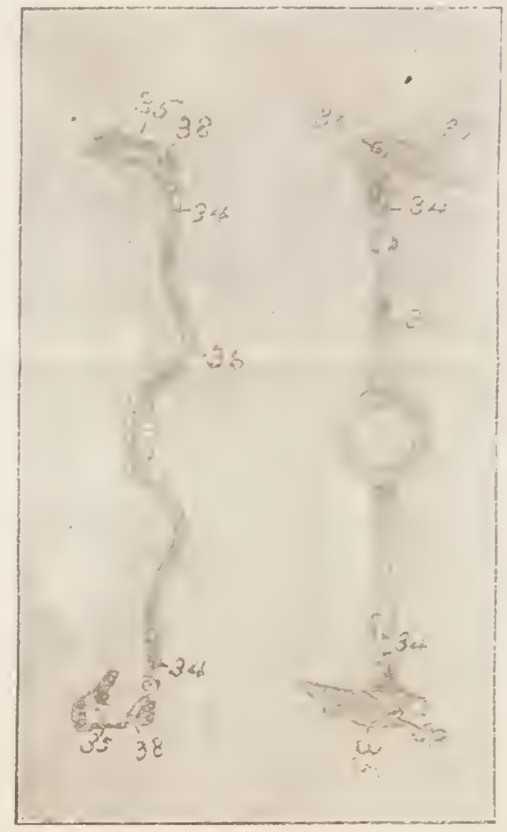
Brush Holders.



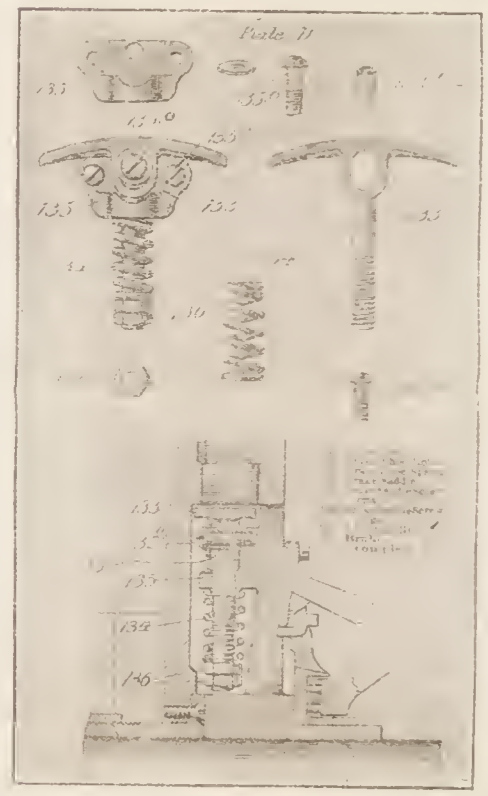
Showing Brushes Pressed Against the Commutator.

Method of Using Sandpaper

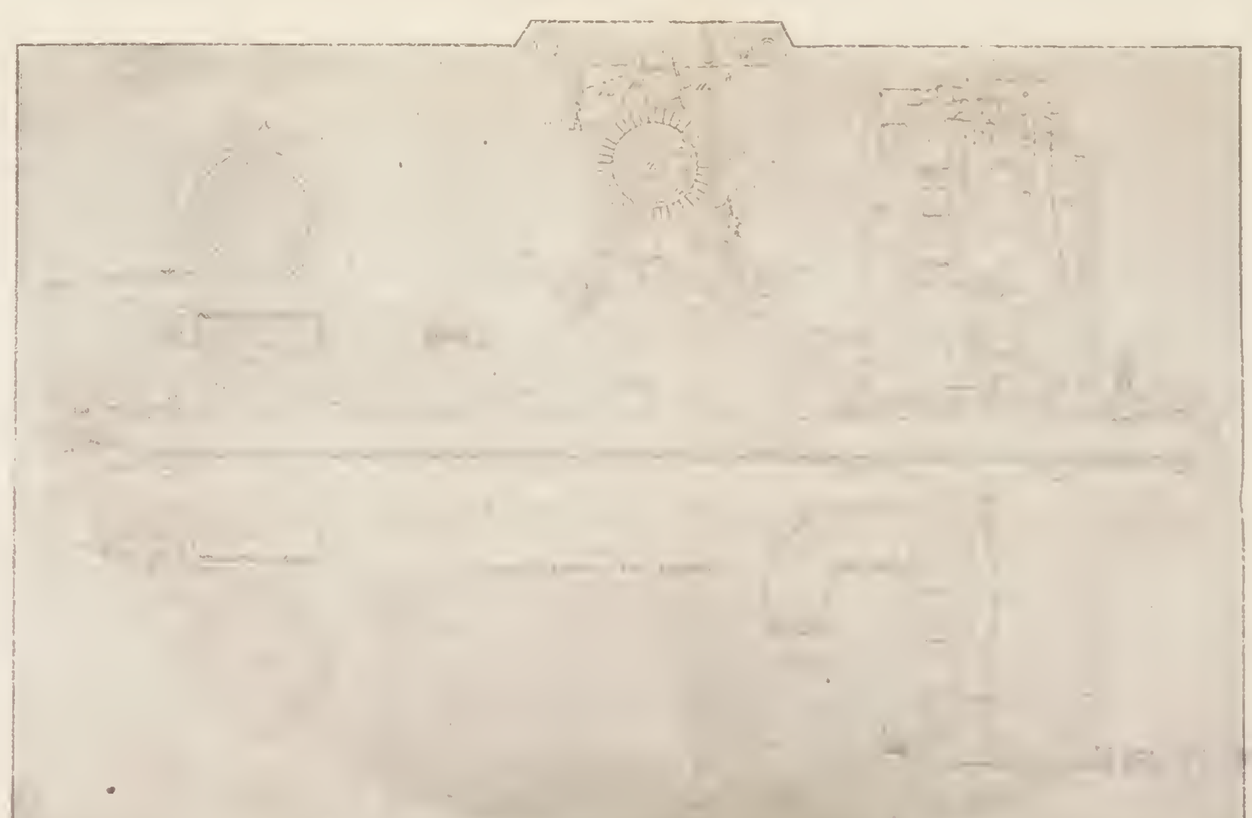
Vertical Section Through Main Casting and Wheel, Showing Passage of Steam.



Showing Cross-Arm, Connecting Link, Governor Stand and Plunger.



Centrifugal Brake.



Pyle Compound Steam Turbine